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A Cross National Comparison on the Awareness of Adopting FOSS4G to NSDI in Developing Countries

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ABSTRACT

In this study, we constructed an assessment framework that was consisted of 9 indicators about functional, economic and public value for FOSS4G adoption to NSDI and alternatives such as data sharing, data management, utilization and construction and derived relative weights using AHP method. For the AHP, we conducted a survey to developing countries' 10 respondents from 9 Asian and Latin American countries. Firstly, result of the survey showed that economic value indicator came in the highest weight with 0.425, followed by functional value indicator with 0.345 and public value indicator with 0.230. Secondly, result of the alternatives analysis showed that data sharing alternative came in the highest adoption rate with 0.824, followed by data management with 0.780, data utilization with 0.778. This means that developing countries want to introduce FOSS4G to their NSDI from economic motivation. This study focused on the comprehensive aspect for adopting FOSS4G to NSDI that is different from the previous researches that were focused on the software engineering aspect to the adoption.

1. INTRODUCTION

Spatial data infrastructure (SDI) plays an important role in the sharing and exchange of spatial information of the country. In this respect, it has also played a major role in the sustainable development of the country's economy and society (Rajabifard & Williamson, 2001). In recent years, Free Open Source Software for Geospatial or FOSS4G provides functionalities that are not inferior to commercial software, which lead to the diffusion of that software to the environment management and natural disaster of public and private sectors (Wawer et al. 2008; Jolma et al., 2008; Herold & Sawada, 2012; Moreno - Sanchez, 2012). More and more countries have been interested in adopting FOSS4G in their National Spatial Data Infrastructure (NSDI) and INSPIRE is acknowledged as one of the best practices of integrating FOSS4G technologies into NSDI (Anguix et al., 2008).

Developing countries which have poor information infrastructures, there are increasing discussions about the adoption of FOSS4G to their NSDI in order to utilize the benefits of the foundation. Especially among the benefits of FOSS4G adoption, low introduction cost and interoperability of software that does not depend on the specific software are frequently suggested

factors. Developing countries, however, have their own economic and technological development stages and different cultural background and institutions, it can vary from country to country what are the important factors for their countries in adopting the FOSS4G to NSDI. So there are differences on the pros and cons of FOSS4G adoption to their NSDI, but little researches have been done to analyze what are the favorable factors for adopting the FOSS4G. Moreover, many researches for introduction criteria of adopting Open Source Software (OSS) were done but those researches are more focused on the software engineering aspect (Jusoh et al., 2012; Jusoh et al., 2014) and researches didn't deal with political or public aspect to FOSS4 adoption.

In this research, we will develop a framework to compare and evaluate the relationships between indicators on the developing countries' public, functional and economic factors in the introduction of FOSS4Gs to their NSDI and conduct a survey of 12 ex- or current government officials from the developing countries about the FOSS4G adoption to their NSDI. To prioritize and derive relative weight of indicators, we used AHP (Analytical Hierarchical Process) method. In the end, we could draw priorities of adopting FOSS4G to NSDI in developing countries and propose a deployment strategy for overcoming the disadvantages when developing countries consider the introduction of FOSS4G to their NSDI.

2. Literature review

This section highlights the research suggested models and frameworks for preferred list of criteria for software selection. The selection criteria FOSS4G to NSDI will be applied to the adoption framework with modification of software quality models and OSS evaluation models.

Many researchers have suggested software quality models. These models are McCall's Quality Model(McCall et al, 1977), Boehm's Quality Model(Boehm et al., 1978), FURPS Quality Model(Grady, 1992), Dromey's Quality Model(Dromey, 1996), and ISO/IEC 9126(ISO, 2001). To evaluate software quality, the qualitative indicators of system characteristics are listed and the quality models explain the relationship between such characteristics. For example, ISO/IEC 9126, an international standard for software quality evaluation, contains a set of software quality metrics related to each of the six quality characteristics: functionality, reliability, usability, efficiency, maintainability, and portability. The model measures any of the six quality characteristics then covert to a percentage value to represent the corresponding quality characteristics. The main advantage of these types of models is models could be applied to evaluate the quality of every type of software product.

The OSS is software which has following features: source code availability to its users and free. To evaluate the OSS, most of software quality characteristics will be applied to the OSS with appropriate modifications. Confino and Laplante(2010) and Ahmad(2011) cited four OSS evaluation models which are the Open Source Maturity Model(OSMM) created in 2003, Open Source Maturity Model(OSMM) created in 2004, the Qualification and Selection of Open Source software model(QSOS), and the Business Readiness Rating(BRR). They also proposed the nine evaluation criteria: functionality, product evaluation, licensing, longevity/pedigree, community, market penetration, documentation, support and code quality. Jusoh et al.(2014) suggested 12 criteria for OSS selection. The criteria suggested are reliability, usability, performance efficacy, functionality, maintainability, security, tangible, reliability, responsiveness, assurance, empathy, competence.

3. Awareness for adopting FOSS4G to NSDI

3.1 AHP methodology

The AHP is a systematic decision making method which was introduced by Thomas L. Saaty

in 1980 (Saaty, 1980). It assesses the relative importance of multiple criteria, compares alternatives for each criterion, and determines an overall ranking of the alternatives. The main advantage of the AHP is that it allows users to take into account a variety of multiple criteria, which rating is based on a multiple-value choice. It has been widely used for a long time in many fields which include research on the selection of the OSS (Open Source Software) product (Jusoh et al., 2014).

In this study, the processes for selecting the FOSS4G to NSDI follow the basic procedure of the AHP method. The first step is to structure a decision problem and selection of criteria. In this step, all the criteria are arranged in a hierarchy and the alternatives are generated. The second step is priority setting of the criteria by pairwise comparing. A numerical weight is derived for each criterion of the hierarchy. All criteria should be compared to one another in a consistent way. In order to verify the consistency of comparison, Consistency Ratio (CR) was proposed. Saaty suggested that CR should satisfy the condition of the value less than or equal to 0.1. However, if CR is less than or equal to 0.2, it can be understood that it has consistency in an acceptable degree. In this study, the condition of CR less than or equal to 0.2 is adopted. In the next step, pairwise comparisons of alternatives on each criterion are carried out. This process is to multiply the alternative weight by the criteria weight to score each alternative. Finally, an overall relative score for each alternative is obtained. The result of the final ranking is presented for users to select the FOSS4G to NSDI.

3.2 Selecting indicators

Some researchers argue that economic aspect such as a low introduction cost (Makanga and Smit, 2010), but others stressed the importance of functionality and opening and sharing of geospatial information (Steiniger and Hunter, 2008). In the research, we constructed an assessment frame into 2 tier indicator system according to proceeding researches. First tier is conceptual indicator and second tier is specific sub-indicators that explain the first tier indicators. First tier assessment indicators deduced 3 indicators such as functional, public and economic values (Table 1). Functional values are explained as evaluating how much helpful FOSS4G is to do one's task, public values are explained as evaluating how much helpful FOSS4G is to achieve value about obtaining geospatial information technologies and knowledge and opening and sharing of the data in each country. Lastly, economic values are explained as evaluating the economic benefits of adoption of FOSS4G.

Second tier consists of 12 specific sub-indicators that mean each indicator has 3 sub-indicators (Table 2). A functional value consists of three sub-indicators that are fit of task, maturity of open source software and usability. A public value consists of achievement of self-reliance of technology, diffusion of spatial information knowledge and openness of spatial information and enhancement of its sharing. Economic value consists of industry ripple effect, total cost of ownership and reusability.

Table 1. First tier assessment indicators for adoption of FOSS4G to NSDI

Indicator	Explanation
Functional value	How much helpful FOSS4G is to do one's task
Public value	How much helpful FOSS4G is to obtain opening and sharing of the data
Economic value	Economic benefits of adoption of FOSS4G

Table 2. Second tier indicators for adoption of FOSS4G to NSDI

Indicator	Sub-indicator	Explanation
Functional value	Fit of task	Achievement of efficiency through the business support
	Maturity of open source software	Completeness of FOSS4G in contrast to commercial software

	Usability	Provision of user-friendly functionality and interface
Public value	Achievement of self-reliance of technology	Contribution to country's technological development
	Diffusion of spatial information knowledge	Acceleration of spatial information knowledge into one's country
	Openness of spatial information and enhancement of its sharing	How many people can be benefited from the FOSS4G based SDI(Spatial Data Infrastructure)
Economic value	Industry ripple effect	Contribution of Geospatial information related industry
	Total cost of ownership	Economic evaluation of Total cost of ownership including construction and maintenance
	Reusability(Interoperability)	Additional cost saving using reusable FOSS4G SW

After determining the weights of individual indicators and sub-indicators, it needs to know which goal is more important than others in adopting the FOSS4G to NSDI. In this respect, we set 4 alternative goals such as data construction, data management, data sharing and data utilization (Figure 1).

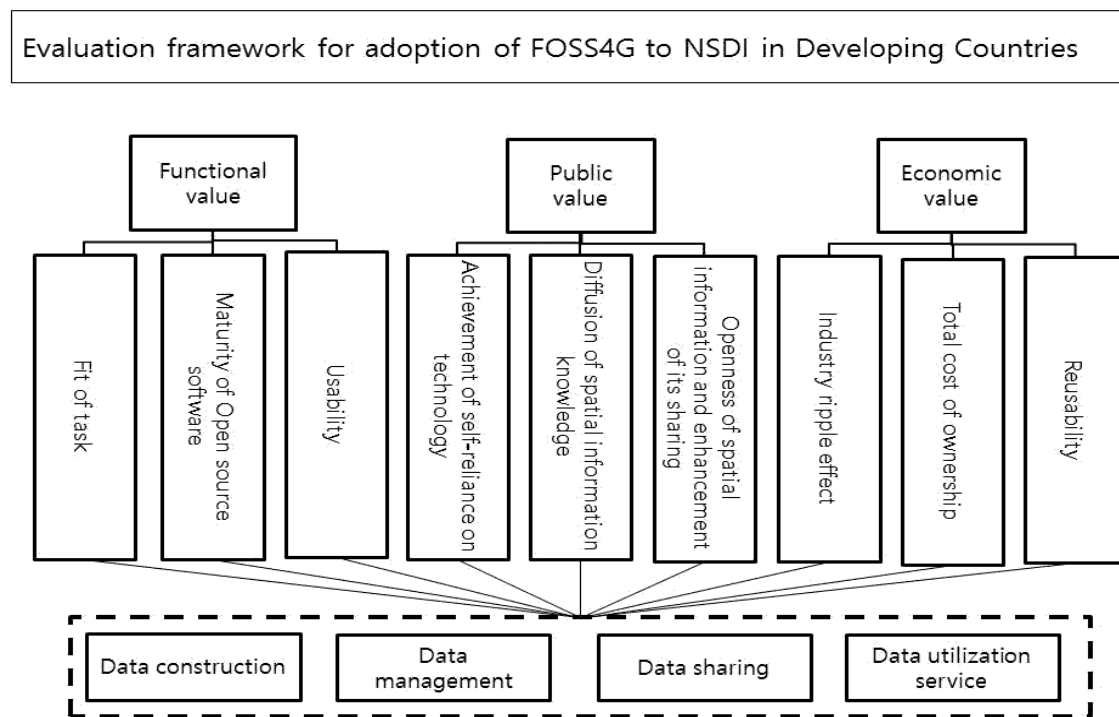


Figure 1. Overall assessment framework.

3.3 Respondents

Survey was conducted to 12 participants, but among the received questionnaires, only 10 were effective for the AHP analysis. That is because we selected questionnaires which are below 0.2 of AHP Consistency Ratio(CR). Participants are from 5 Asian and 3 Latin American countries who are

ex or current government officials in those countries. Asian participants are from Vietnam, Sri Lanka, Cambodia, Iraq and Philippines and Latin American participants are from El Salvador, Peru and Colombia. The respondents are now studying in Korea and with the help of International Urban Development Cooperation Center in Korea Land and Housing Corporation which is government company. Participants' ages are from late 20' to 40's and their affiliations of their countries are urban planning, construction, environment department.

3.4 Results

Result of the survey showed that economic value indicator came in the highest weight with 0.425, followed by functional value indicator with 0.345 and public value indicator with 0.230 (Table 3). Among the economic value sub-indicators, total cost of ownership has the highest weight with 0.493. That means developing countries have not sufficient budget and they mostly focused on saving of expenses. Among the functional value sub-indicators, fit of task has the highest weight with 0.581. We can presume that developing countries place a high value on business utilization. In the public value sub-indicators, openness of spatial information and diffusion of spatial information get a similar weight.

Table 3. Weight

Criteria	Weight
Functional value	0.345
Fit of task	0.581
maturity of open source software	0.138
usability	0.281
Public value	0.230
Achieve of self-reliance of technology	0.121
Diffusion of spatial information knowledge	0.435
Openness of spatial information and enhancement of its sharing	0.444
Economic value	0.425
Industry ripple effect	0.222
Total cost of ownership	0.493
Reusability	0.284

Finally we assess the goal for adopting FOSS4G to NSDI. Result of the survey showed that Data sharing alternative came in the highest adoption rate with 0.824, followed by data management with 0.780, data utilization with 0.778 (Table 4). That means although data sharing is slightly important than other alternatives, all alternatives have similar importance in adopting FOSS4G to their NSDI.

Table 4. Weight for the adoption of alternatives

	adopt	Not adopt
Data construction	0.774	0.226
Data management	0.780	0.220
Data sharing	0.824	0.176
Data utilization	0.778	0.222

4. Conclusion

In this study, we conducted a survey to find the awareness of FOSS4G introduction of developing countries' 10 respondents from 9 Asian and Latin American countries. We constructed a framework that was consisted of 9 indicators about functional, economic and public values for FOSS4G adoption to NSDI and investigated relative weights between indicators using AHP method. In the result, we identified that economic value is the highest value in developing countries. This means that developing countries want to introduce FOSS4G to their NSDI from economic motivation. Also weight of alternatives which are NSDI alternatives from FOSS4G such as data sharing, management, utilization, etc., were analyzed. As a result, those alternatives have similar result of high adoption rate. This means that those alternatives are also important in developing countries. This study focused on the comprehensive aspect for adopting FOSS4G to NSDI that is different from the previous researches that were focused on the software engineering aspect to the adoption. In the future study, additional survey is needed to find the differentiated adoption factors by country, by economic status and by political condition, etc.

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